



Training event “Climate change and air quality: challenges and objectives for the atmospheric research.”

Use of Ny-Ålesund Climate Change Tower atmospheric data to assess the occurrence of heatwaves

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IR0000032 – ITINERIS, Italian Integrated Environmental Research Infrastructures System
(D.D. n. 130/2022 - CUP B53C22002150006) Funded by EU - Next Generation EU PNRR-
Mission 4 “Education and Research” - Component 2: “From research to business” - Investment
3.1: “Fund for the realisation of an integrated system of research and innovation infrastructures”



Who am i!

since Sept. 2023

Technologist TD (PNRR)@ISP-CNR

- Data ingestion and management (polar repository)
- Virtual research environment development
- Machine learning advocate



Alice Cavaliere

“If We Knew What We Were Doing, It Would Not Be Called Research, Would It?”

Past years

UNIFI

Computer Science Engineering (MSc)

PhD

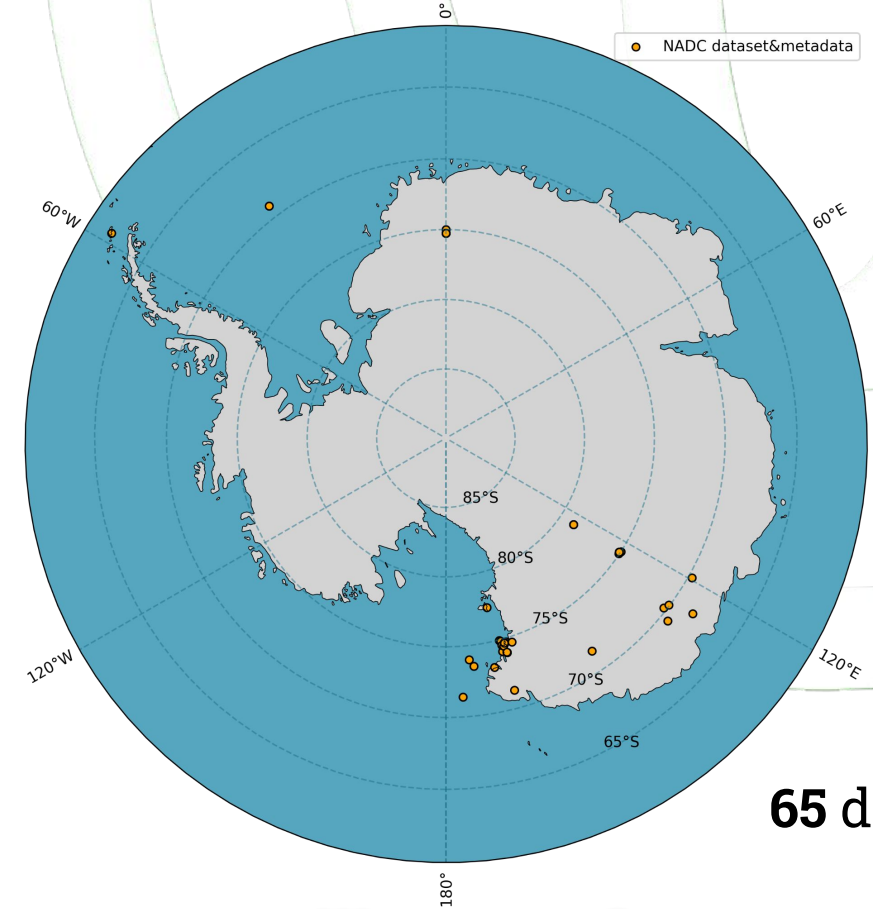
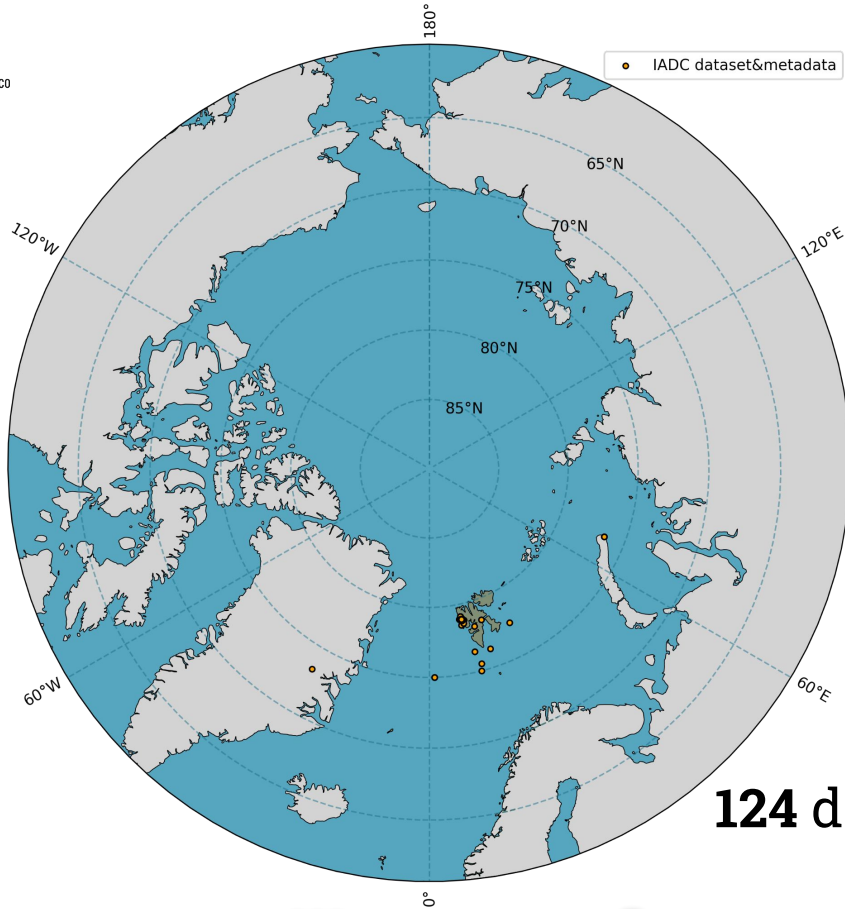
Information engineering
(Nonlinear dynamics and complex system, cycle XXX)

PostDOC@UNIFI/IBE-CNR

Software development & data mining/machine learning (Air quality sensors network & remote sensing)

<https://iandc.pnra.aq>

<https://iadc.cnr.it>



124 dataset
17 DOI

65 dataset
3 DOI



40%
Climatology, Meteorology, Chemistry and physics of the atmosphere

24%
Marine and oceanographic research

10%
Ecosystem biodiversity, Geology and Glaciology

26%
Bioma, Inland water,

37%
Climatology, Meteorology, Chemistry and physics of the atmosphere

12%
Marine oceanographic research

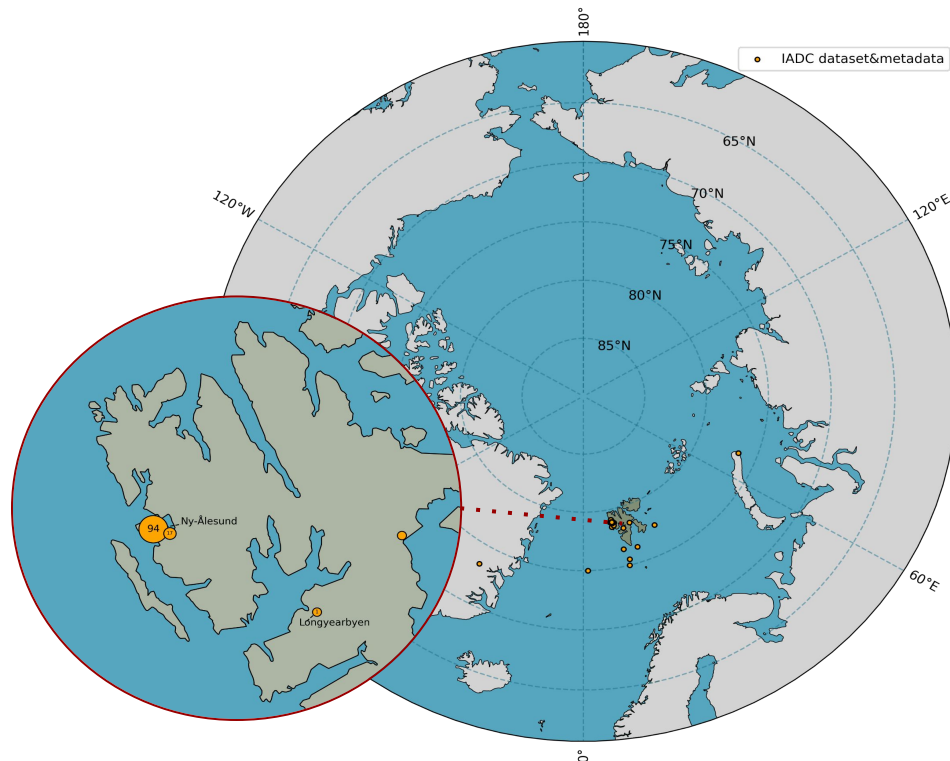
9%
Ecosystem biodiversity, Geology and Glaciology

42%
Biota, inland water, health,society

Italian Arctic Data Center (IADC)

The IADC handles both Data and Metadata following a **FAIR** approach. Is made by two parts:

- GeoNetwork-based metadata catalogue
- ERDDAP-based data server and repository



Actually IADC consist in:

- 124 datasets (including both data and metadata)
- 17 DOIs (Digital Object Identifiers)



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Chemistry and physics of the
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Inland water,
Bioma

The **Italian Arctic Data Center** [1] aims to collect scientific contributions from research by Italian institutions working in the Arctic through a metadata catalogue based on **GeoNetwork**.

- **GeoNetwork** [2] is an open-source Spatial Data Catalogue System for managing and cataloging metadata records (i.e **ISO 19115**). It uses **keywords** from controlled vocabularies (thesauri).
- It features a **search engine** that allows free-text searches or filtered searches based on keywords, resource types, organizations and institutions, people, projects, etc.



Fig. 1: IADC GeoNetwork web interface.

[1]<https://iadc.cnr.it>

[2]<https://geonetwork-opensource.org/>

Natural language query (LLM)

What data is available to analyze air temperature trends in Svalbard?

Okay, let's try to figure out which dataset the user can use to plot the air temperature trend in Svalbard. First, I need to look through the context provided and find datasets that include air temperature data for Svalbard.

Looking at the first context entry, it mentions "Climate Change Tower Meteorological Data." The content includes variables like HUMIDITY, AIR TEMPERATURE, BOUNDARY LAYER WINDS, etc., and specifies locations such as ARCTIC, SVALBARD AND JAN MAYEN. This seems promising because it directly relates to air temperature and is located in Svalbard.

The second context entry talks about fractional snow cover

...

< think >



The dataset "Climate Change Tower Meteorological Data" could be used for plotting air temperature trends in Svalbard. It contains AIR TEMPERATURE measurements and is available for online visualization.

Dataset:

- **Name:** Climate Change Tower Meteorological Data
- **Link:** <https://metadata.iadc.cnr.it/geonetwork/srv/api/records/cb5b0a66-5c66-4c19-8de9-b1a7b7373f34>
- **OpenDAP URL:** https://data.iadc.cnr.it/erddap/tabledap/cct_meteo_d2

Here is an example of how you could use ERDDAP to access and plot the data:

```
from erddapy import ERDDAP

# Set up the connection to the ERDDAP server
e = ERDDAP(
    server="[https://data.iadc.cnr.it/erddap](https://data.iadc.cnr.it/erddap)",
    protocol="tabledap",
)
e.dataset_id = "cct_meteo_d2" # Replace with your dataset ID if different
# Convert the data to a pandas DataFrame
df = e.to_pandas()
# Plot air temperature over time
import matplotlib.pyplot as plt

plt.figure(figsize=(12, 6))
plt.plot(df.index, df['AIR_TEMPERATURE'])
plt.xlabel('Time')
plt.ylabel('Air Temperature (°C)')
plt.title('Air Temperature Trend in Svalbard')
plt.show()
```

This code will fetch and plot the air temperature data from the specified dataset.

Amundsen-Nobile Climate Change Tower (CCT)



- o 34 meters high
- o 17 modules
- o 16 years of measurements

Instrument suites for measuring standard atmospheric parameters—temperature, relative humidity, wind speed, and wind direction—have been installed at four different heights at CCT. Data and metadata are recorded in real time and stored on the Italian Arctic Data Center.



Atmosphere

Temperature, relative humidity, wind speed and direction



Radiation

Radiation balance, visible and infrared components



Snow

Depth, temperature

CCT temperatures are recorded at 2m, 5m, 10m, and 33m, with three levels of quality assurance (QA): **fabric calibration**, **calibration chamber** correction, **sensor physical threshold** verification, and **columnar difference threshold** assessment [2,3].

- An additional QA measure includes implementing outlier and anomaly detection for minute-level data utilizing some ML algorithm as the **Isolation Forest (IF)** and **Local Outlier Factor (LOF)**[4,5]

CCT 2024 Temperature 2m outlier (Ny-Ålesund, Norway)

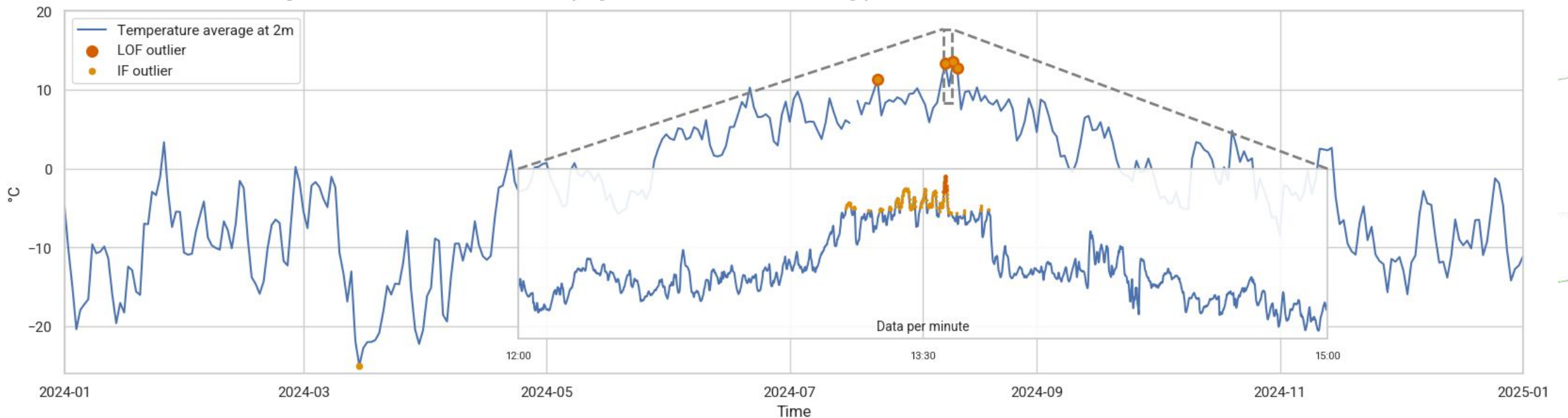
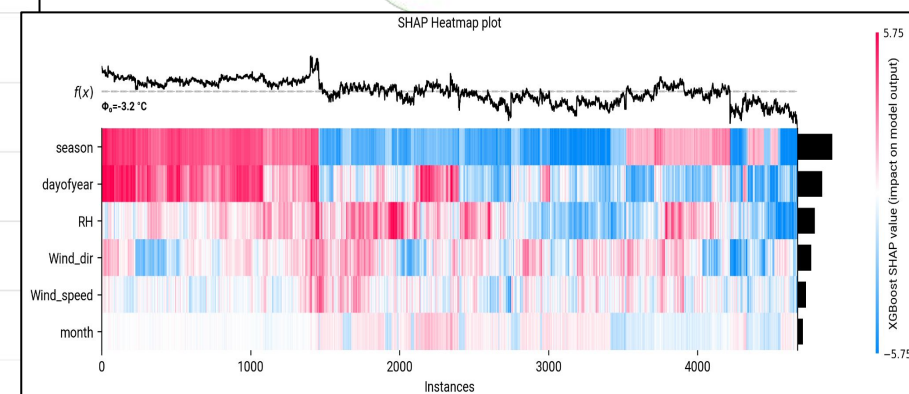
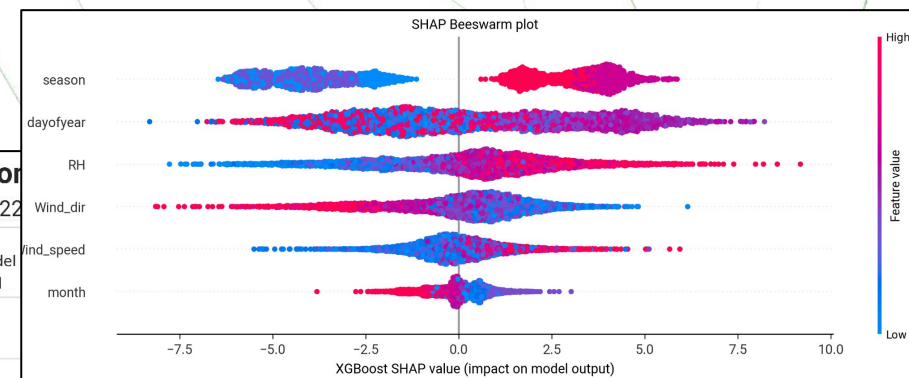
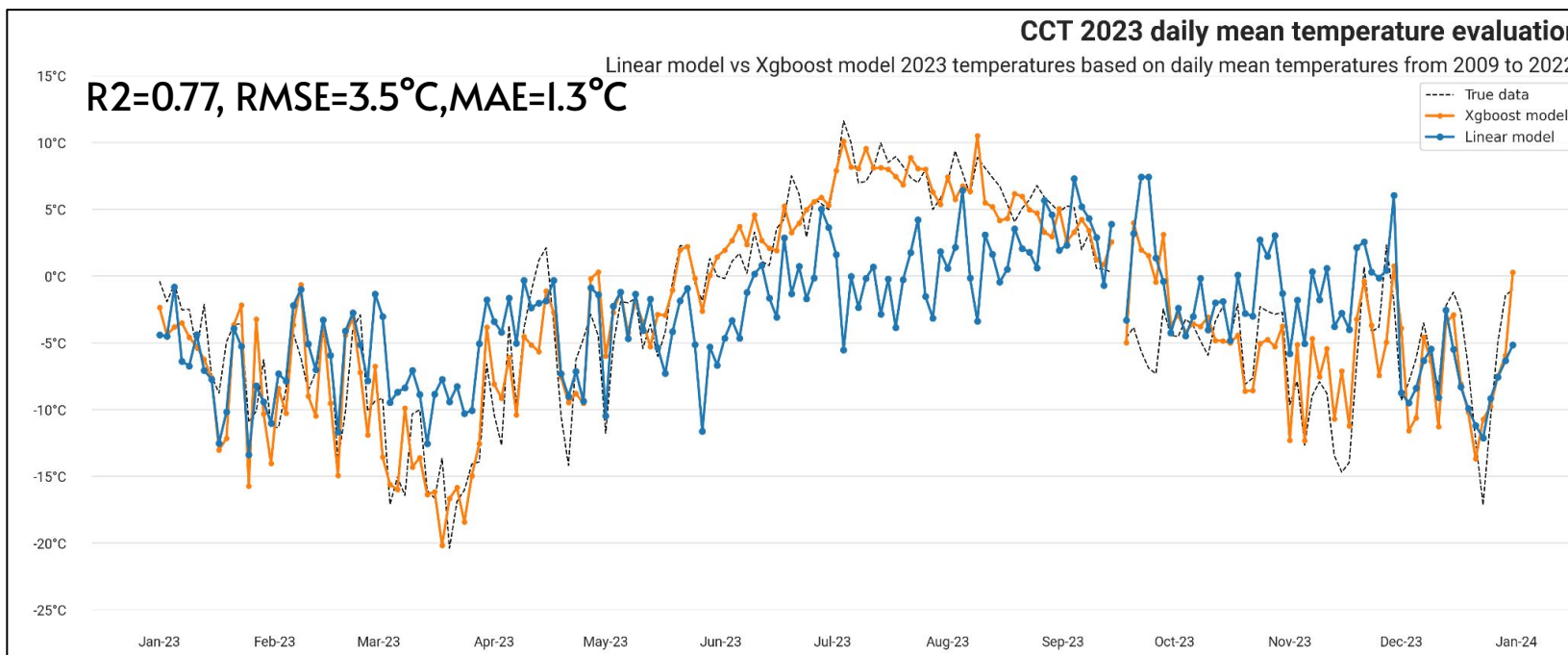


Fig. 4: Time series of the average temperature at 2m from January 2024 to January 2025. A zoomed-in inset highlights temperature variations in August 2025.. Yellow and red markers indicate outliers detected using the Isolation Forest (IF) and Local Outlier Factor (LOF).

- [2] Mazzola, M., Viola, A. P., Lanconelli, C., & Vitale, V. (2016). Atmospheric observations at the Amundsen-Nobile climate change tower in Ny-Ålesund, Svalbard. *Rendiconti Lincei*, 27, 7-18.
- [3] Coppa, G., Musacchio, C., Becherini, F., Mazzola, M., Viola, A., & Merlone, A. (2024). On-site calibration of instruments in the Arctic: assessment of temperature records at Climate Change Tower in Ny-Ålesund, Svalbard. *Arctic Science*, 10(4), 643-652.
- [4] Liu, Fei Tony, Ting, Kai Ming and Zhou, Zhi-Hua. "Isolation-based anomaly detection." *ACM Transactions on Knowledge Discovery from Data (TKDD)* 6.1 (2012): 3.

ML is also used to make some experiment about forecast and inference. Below a comparison between a linear regression model and **XGBoost** for evaluating 2023 temperatures using CCT data spanning from 2009 to 2022 is presented. In addition to temperature data, others features at 2 meters such as relative humidity, wind direction and speed, along with temporal attributes like season and month, were incorporated into the models.

Additionally, the **SHAP** [5] values for XGBoost are presented in the sections on the right, shedding light on the importance of each feature in the temperature evaluation process for a “black box” model.



[5] Lundberg, S. M., & Lee, S. I. (2017). A unified approach to interpreting model predictions. Advances in neural information processing systems, 30.

Ny-Ålesund stripes!

Ny-Ålesund (Norway) Warming stripes [°C]

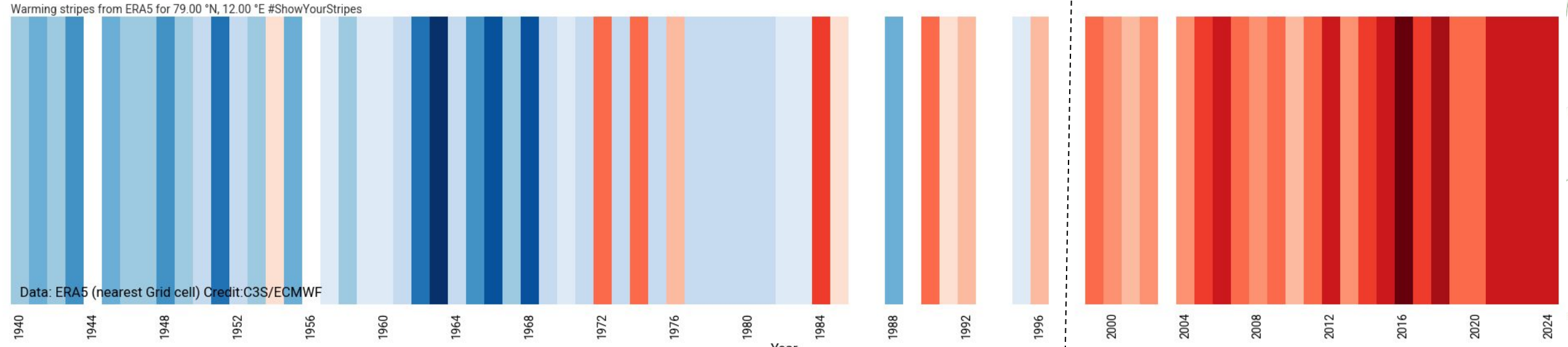
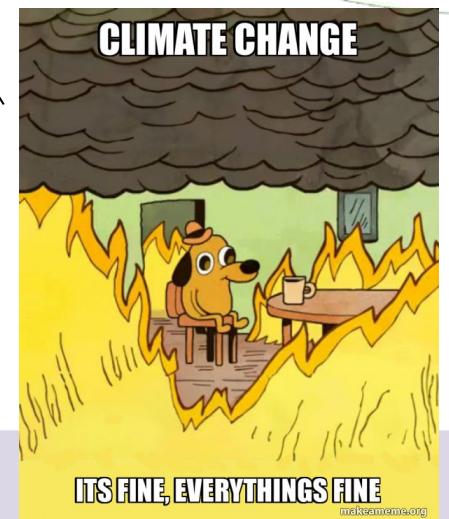
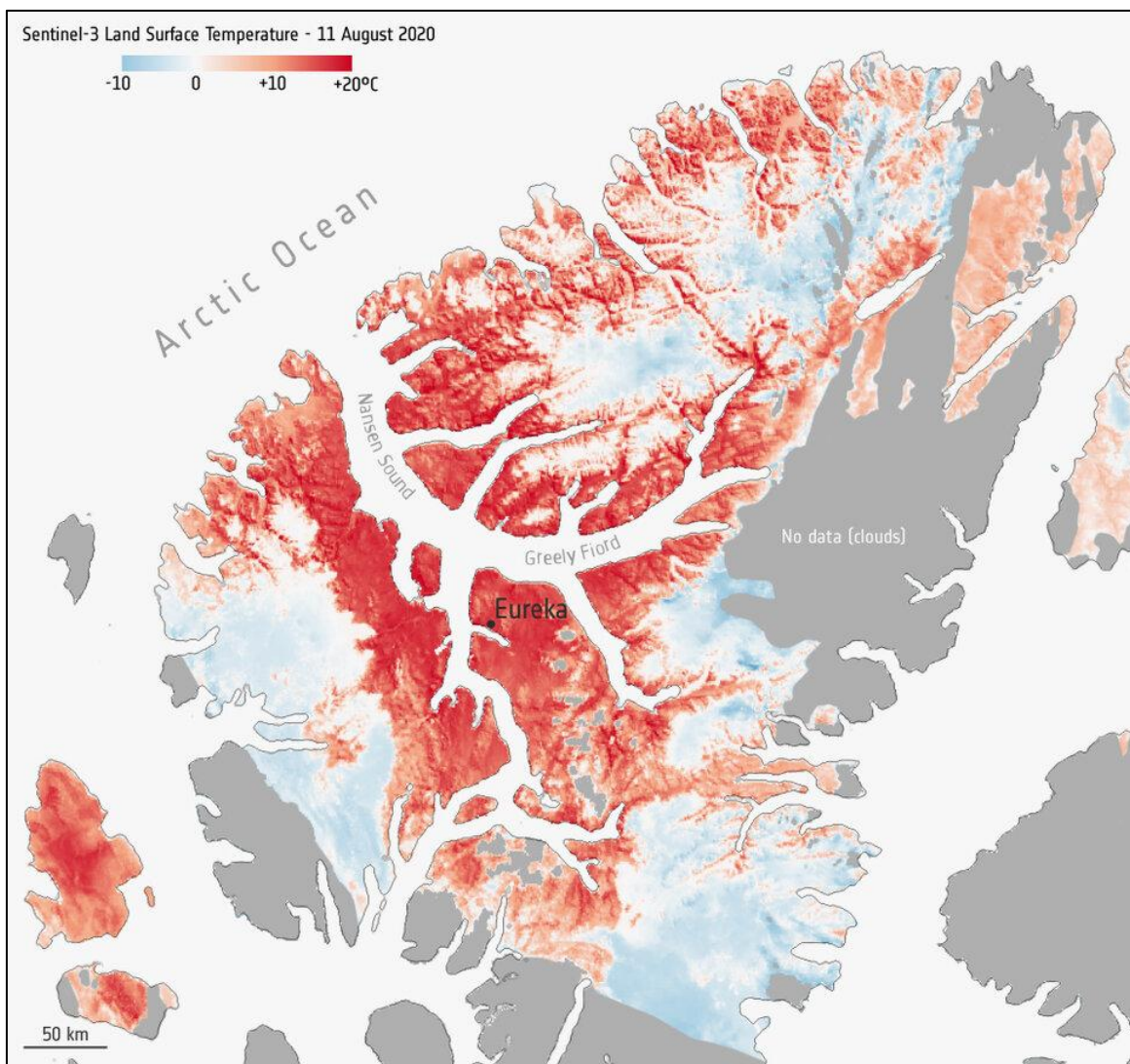


Fig. 5: Each vertical stripe represents the annual temperature anomaly relative to a historical baseline.

Climate Warming Stripes (Ed Hawkins, University of Reading) transform climate data into a powerful visual. Each stripe represents one year and the color corresponds to whether the temperature was warmer than (red) or cooler than (blue) the long-term average.



p.s : Show Up for Stripes Day will be on June 21 2025! #ShowYourStripes



[6] https://www.esa.int/Applications/Observing_the_Earth/Monitoring_the_Arctic_heatwave

- According to the [Copernicus Climate Change Service](#), July 2020 was the third warmest July on record for the globe, with temperatures 0.5°C above the 1981-2010 average.
- Extreme air temperatures were also recorded in northern Canada. On 11 August, Nunavut's Eureka Station, located in the Canadian Arctic at 80 degrees north latitude, recorded a high of 21.9°C – which were reported as being the highest temperature ever recorded so far north.
- The image [6] shows the land surface temperature recorded on 11 August around Eureka. This map has been generated using data from [Copernicus Sentinel-3's](#) Sea and Land Surface Temperature Radiometer
- The high temperatures fuelled an outbreak of wildfires in the Arctic Circle.
- Wildfire smoke releases a wide range of pollutants including carbon monoxide, nitrogen oxides and solid aerosol particles.

A day in which the temperature anomaly is higher than its seasonal 90th pct is defined Arctic hot day (AHD or more briefly HD). An Arctic heatwave (AHW or more briefly HW) is defined as a period of at least 3 consecutive HDs [7].

CCT 2020 daily mean temperature (Ny-Ålesund, Norway)

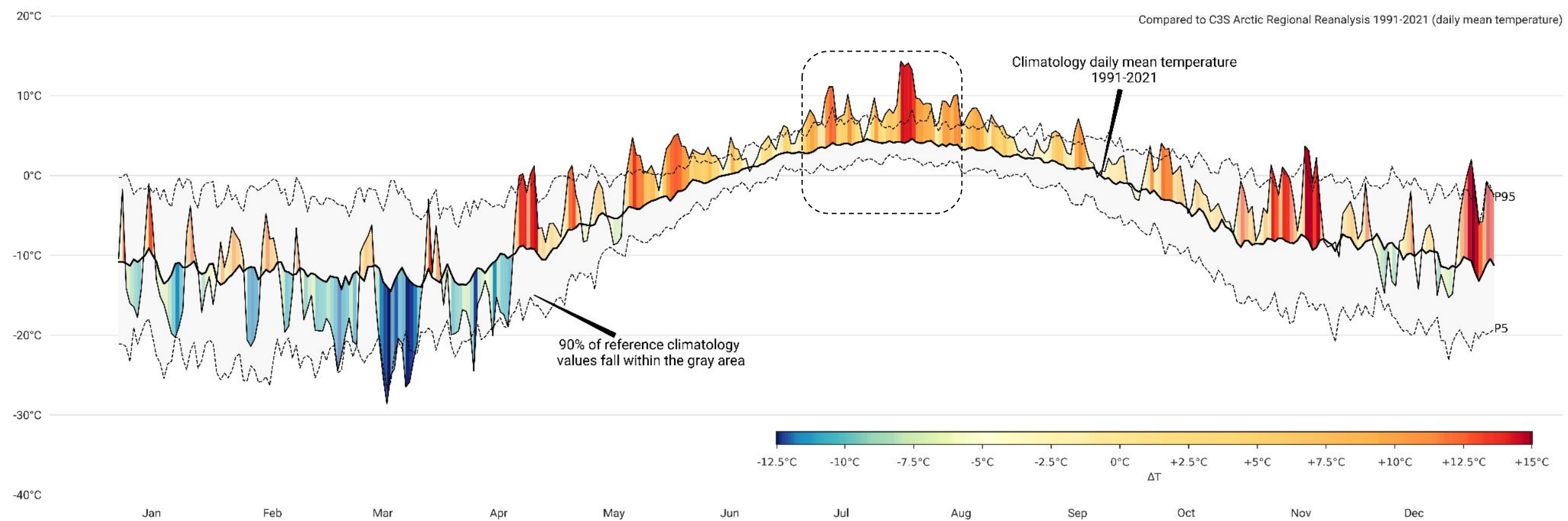
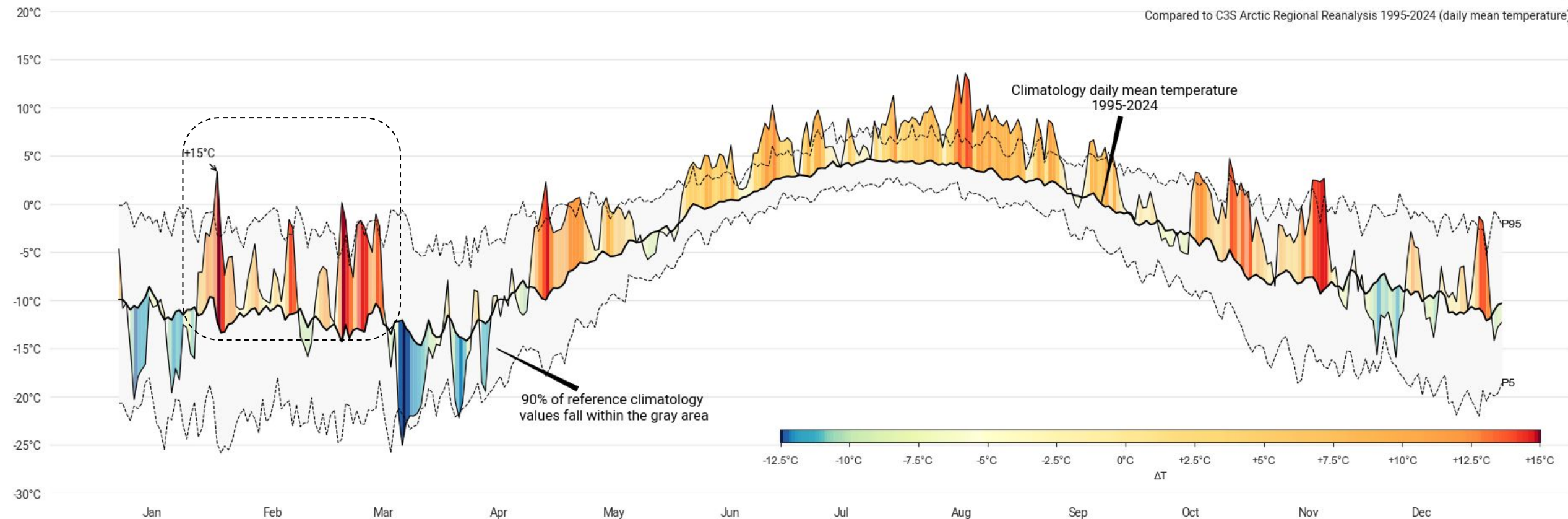


Fig. 6: Comparison of 2-meter air temperature data from the Climate Change Tower (2020) with the C3S Arctic Regional Reanalysis (CARRA) over the East domain [7] Lorenzi, G. "Definition and classification of Arctic heatwaves.", University of Bologna, 2019/2020

Changes like summer heatwaves, unusually mild winters and the early onset of spring have all sorts of consequences for cold-adapted Arctic wildlife!

CCT 2024 daily mean temperature (Ny-Ålesund, Norway)

Compared to C3S Arctic Regional Reanalysis 1995-2024 (daily mean temperature)



Data: C3S Arctic Regional Reanalysis (CARRA-East domain) & CCT IADC data; Graph: inspired by Jan Kühn, <https://yotka.org>

Fig. 7: Comparison of 2-meter air temperature data from the Climate Change Tower (2024) with the C3S Arctic Regional Reanalysis (CARRA) over the East domain.

Some of the many issues raised by the rapid climate evolution the Arctic:

1. contributes to the thawing of **permafrost**, Arctic permafrost soils contain large quantities of organic carbon and materials left over from dead plants that cannot decompose;
2. when permafrost melts it releases **methane** and **carbon dioxide** into the atmosphere (a vicious cycle)
3. the reduction of Arctic sea ice contributes to the **Arctic Amplification** especially because of the ice–albedo feedback, increasing mid-latitude extreme weather events;
4. subsistence of the **Inuit and indigenous communities** is susceptible to changes in wildlife populations and access to hunting areas.



Fig. 8: Indigenous participants attending the ICARP IV Summit 2025, Boulder, Colorado, USA from 25 – 28 March 2025



THANKS!

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Climate Change Tower (Ny-Ålesund)
Credits: Rosamaria Salvatori, 2011



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dell'Università
e della Ricerca

